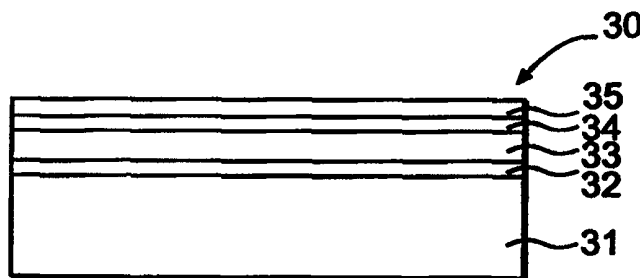




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(54) Title: AN ORGANIC LIGHT EMITTING DIODE DEVICE FOR USE WITH OPAQUE SUBSTRATES

**(57) Abstract**

A display device for use on an opaque substrate is disclosed. The device includes an organic light emitting diode device located on the opaque substrate. The opaque substrate includes an integrated circuit chip. The organic light emitting diode device includes an opaque bottom electrode, an organic stack, and a transparent top electrode. The opaque bottom electrode is reflective and is located on the opaque substrate.

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AN ORGANIC LIGHT EMITTING DIODE DEVICE FOR USE WITH OPAQUE SUBSTRATES

Cross Reference To Related Patent Application

This application relates to and claims priority on U.S. Provisional Application Serial Number 60/085,475, filed May 14, 1998.

Field of the Invention

5 The present invention relates to an organic light emitting diode (OLED) device for use with opaque substrates. In particular, the OLED device is usable with an opaque substrate such as silicon wafers containing active matrix circuitry.

Background of the Invention

10 Fig. 1 discloses a known organic light emitting diode device **10**. The organic light emitting diode device **10** includes a glass substrate **11**. A transparent hole-injecting anode or electrode **12** formed of indium-tin oxide (ITO) is located on the glass substrate **11**. An organic stack **13** is located on the anode **12**. The anode **12** forms the first or bottom layer of the stack **13**. A metal cathode **14** is located on top of the organic stack **13**. In the device **10**, light is emitted in a downward direction through the electrode **12** and the glass substrate **11**.

15 Fig. 2 discloses a known fully transparent organic light emitting diode device **20**. The organic light emitting diode device **20** includes a glass substrate **21**. A transparent electrode **22** formed of ITO is located on the glass substrate **21**. An organic stack **23** is located on the electrode **22**. A buffer layer **24** is formed on the organic stack **23**. Finally, another electrode **25** formed of ITO is located on the buffer layer **24**. In this arrangement, the electrode **25** and
20 buffer layer **24** together function as a cathode. In the device **20**, light is emitted in both an upward direction through buffer layer **24** and electrode **25** and a downward direction through the electrode **22** and glass substrate **21**.

The above-described devices **10** and **20** are unsuitable for use in active matrix organic light emitting diodes.

Objects of the Invention

It is an object of the present invention to provide a display device for use on opaque substrates.

5 It is another object of the present invention to provide a display device for use on a substrate containing active matrix circuitry.

It is another object of the present invention to provide a display device having a bottom electrode that is opaque.

It is another object of the present invention to provide a display device having a bottom electrode that is reflective for improved light output.

10 It is another object of the present invention to provide a display device having a top transparent electrode.

It is another object of the present invention to provide a display device having a bottom electrode that is an anode.

15 It is another object of the present invention to provide a display device having a bottom electrode that is a cathode.

Summary of the Invention

The present invention is directed to a display device comprising an opaque substrate, and an organic light emitting diode device located on the opaque substrate. The opaque substrate may include an integrated circuit chip. The integrated circuit chip may be a Si
20 integrated circuit chip.

The organic light emitting diode device may include an opaque bottom electrode, an organic stack, and a transparent top electrode. The opaque bottom electrode may be located on the opaque substrate. The organic stack may include a plurality of layers. The plurality of layers may include at least a hole transport layer and an emitter layer.

25 Brief Description of the Drawings

The invention will be described in conjunction with the following drawings in which like reference numerals designate like elements and wherein:

Fig. 1 is a schematic view of a known organic light emitting diode device;

Fig. 2 is a schematic view of another known organic light emitting diode device that is capable of emitting light in an upward and downward direction; and

Fig. 3 is a schematic view of an organic light emitting diode device in accordance with an embodiment of the present invention.

Detailed Description of the Preferred Embodiment

Fig. 3 discloses an organic light emitting diode device **30** according to an embodiment of the present invention. The organic light emitting diode device **30** includes a substrate **31**. A first electrode **32** is located on the substrate **31**. An organic stack **33** is located on the first electrode **32**. A buffer layer **34** is located on top of the organic stack **33**. A second electrode **35** is located on top of the buffer layer **34**.

The organic light emitting diode device **30** preferably includes active matrix circuitry. The substrate **31** preferably contains the active matrix circuitry, such as, for example, an integrated circuit chip. The substrate **31** comprises a silicon wafer containing the active matrix circuitry. Accordingly, the substrate **31** is opaque. Because the substrate **31** is opaque, light does not pass through the substrate **31**. As such, the organic light emitting device **30** is an upwardly or top light emitting device. With this arrangement, the second electrode **35** is a transparent electrode.

To maximize the amount of light escaping through the transparent electrode **35**, it is desirable to use a first electrode **32** having good reflective properties. The reflective electrode **32** under the organic stack **33** will reflect the light generated in the organic stack **33** in an upward direction to the transparent electrode **35**. The first electrode **32** is opaque. The preferred materials having suitable reflective properties for forming the electrode **32** differ depending on whether the first electrode **32** is an anode or a cathode.

When the first electrode **32** is an anode, it is desirable that the metal forming the first electrode **32** has a high work function. This permits the first electrode **32** to be a more efficient hole-injector. Suitable materials forming a first electrode **32** that functions as an anode include platinum, gold, nickel, chromium, tungsten, molybdenum, palladium, copper, as well as, alloys incorporating these materials. It, however, is contemplated that the present invention is not limited to the above-described metals and alloys for forming the anode;

rather, other metals and alloys having good reflective properties and a high work function are considered to be within the scope of the present invention.

When the first electrode **32** is a cathode, it is desirable that the metal forming the first electrode **32** has a low work function. This improves electrode efficiency. Suitable materials for forming a first electrode **32** that functions as a cathode include magnesium, calcium, lithium, aluminum, scandium, as well as, alloys incorporating the metals. It, however, is contemplated that the present invention is not limited to the above-described metals and alloys for forming the cathode; rather, other metals and alloys having good reflective properties and a low work function are considered to be within the scope of the present invention.

It is possible to modify the work function of the metal used to form the first electrode **32** by applying a thin layer (e.g., less than 10 nm) of another material on the metal. For example, a thin layer of oxide increases the work function of molybdenum. A thin layer of LiF on aluminum causes the aluminum to behave like a material having a lower work function.

An ion sputter damaged Alq or CuPc cathode with a transport top conductor, such as, for example, ITO or indium zinc oxide (IZO) is also considered to be within the scope of the present invention.

The organic stack **33** includes at least a hole transport layer and an emitter layer. The organic stack **33** may further include a hole injection layer containing a layer of CuPc, for example, and an electron transport layer.

The second electrode **35** is a transparent electrode to permit light to be emitted from the top of the device **30**. The second electrode **35** may be formed from ITO, IZO or a thin layer of metal or organometallic (e.g., CuPc) in conjunction with ITO or IZO. The second electrode, however, is not limited to these materials, other materials having suitable properties for a transparent electrode are considered to be well within the scope of the present invention.

While this invention has been described in conjunction with specific embodiments thereof, it is evident that many alternatives, modifications and variations will be apparent to

those skilled in the art. Accordingly, the preferred embodiments of the invention as set forth herein are intended to be illustrative, not limiting. Various changes may be made without departing from the spirit and scope of the invention as defined in the following claims.

WHAT IS CLAIMED IS:

1. A display device comprising:
an opaque substrate; and
an organic light emitting diode device located on said opaque substrate.
2. The display device according to Claim 1, wherein said opaque substrate includes an integrated circuit chip.
3. The display device according to Claim 2, wherein said integrated circuit chip is a Si integrated circuit chip.
4. The display device according to Claim 1, wherein said organic light emitting diode device comprises:
an opaque bottom electrode;
an organic stack; and
a transparent top electrode.
5. The display device according to Claim 4, wherein said opaque bottom electrode is located on said opaque substrate.
6. The display device according to Claim 5, wherein said opaque substrate includes an integrated circuit chip.
7. The display device according to Claim 6, wherein said integrated circuit chip is a Si integrated circuit chip.
8. The display device according to Claim 4, wherein said opaque bottom electrode is reflective.
9. The display device according to Claim 8, wherein said opaque bottom electrode is an anode.
10. The display device according to Claim 9, wherein said opaque bottom electrode is formed from a material having a high work function.
11. The display device according to Claim 8, wherein said opaque bottom electrode is a cathode.
12. The display device according to Claim 11, wherein said opaque bottom electrode is formed from a material having a low work function.

13. The display device according to Claim 4, wherein said organic stack includes a plurality of layers.

14. The display device according to Claim 13, wherein said plurality of layers includes at least a hole transport layer and an emitter layer.

15. The display device according to Claim 1, wherein said opaque substrate is an integrated circuit chip.

16. The display device according to Claim 15, wherein said integrated circuit chip is an Si integrated circuit chip.

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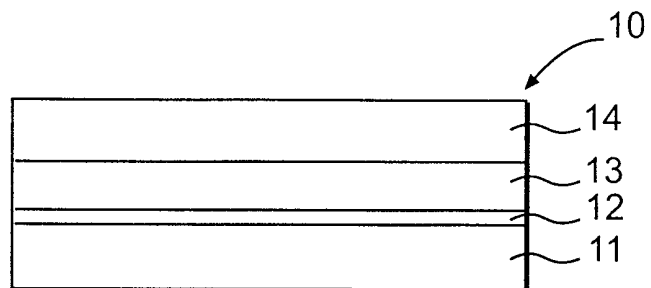


FIG. 1
(PRIOR ART)

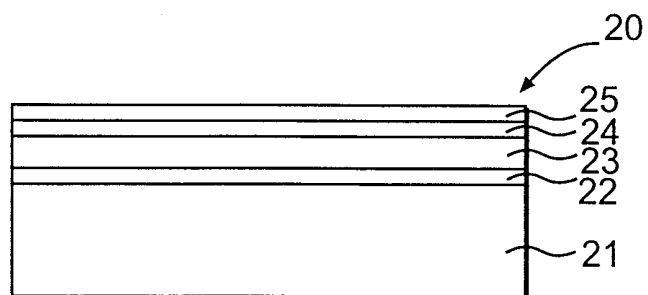


FIG. 2
(PRIOR ART)

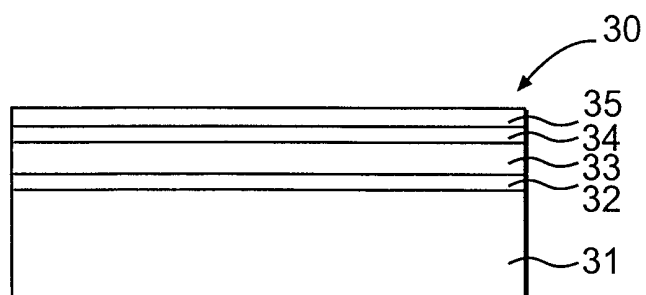


FIG. 3